Water Resources Development Commission
Environmental Working Group
Arizona's Inventory of Water-Dependent Natural Resources

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SUMMARY OF FINDINGS & RECOMMENDATIONS

OVERVIEW

The Inventory of Arizona's Water-Dependent Natural Resources provides the Water Resources Development Commission (WRDC) with a significant new tool to evaluate the relationship between the state's waters and the environmental resources those waters support. Developed by the Environmental Working Group of the WRDC in 2011, the Inventory catalogs a wide-range of existing data and research on natural resources associated with rivers, streams, wetlands, lakes and springs throughout Arizona. It builds upon the Arizona Department of Water Resources' (ADWR) *Arizona Water Atlas* by focusing on the state's riparian and aquatic habitats, the fish, wildlife and natural communities these habitats support, and the conditions currently supporting these resources.

Organized by groundwater basin, the Inventory includes this Summary of Findings, a written overview of this effort along with recommendations based on these findings, and the following:

Tables – tables for each of Arizona's 51 groundwater basins present information on the sub-basins, watersheds, counties, water features, riparian and aquatic-dependent wildlife, and flow volumes supporting these resources associated with each basin.

Maps –groundwater basin and county maps visually represent the water-dependent natural resources characterized in the tables as well as other features.

Basin Summaries – written summaries for each groundwater basin provide additional information in narrative form.

Methodology – written explanation of the methodology and sources used to create the tables, maps, and summaries.

References – a record of the studies and research used to complete this Inventory.

To best understand the water-dependent natural resource information included in this Inventory, the tables, maps, and summaries for each basin should be used conjunctively.

The Inventory of Arizona's Water-Dependent Natural Resources clearly documents the diversity of natural resources that exist in the State of Arizona. Arizona's water and environmental resources both enhance the economy and provide citizens a high quality of life. The inventory denotes some of the following findings about Arizona:

Arizona's 51groundwater basins are environmentally unique and diverse.
More than 5,000 miles of perennial flow are estimated (ADEQ & USGS, 2007).
Upwards of one million acres of riparian areas exist (AGFD, 1994).
More than $1.7 billion is generated from wildlife-based recreation activities (Silberman, 2001; Southwick Associates, 2002 & 2003).

Another $1.7 billion is produced from bird watching activities (Silberman, 2001; Southwick Associates, 2002 & 2003).
181 sensitive wildlife species tracked by the Arizona Heritage Data Management System (HDMS) are supported by water-dependent natural resources (AGFD, 2011).

The Inventory is a significant accomplishment that provides a better understanding of Arizona's water-dependent natural resources as we look at how to meet statewide water demands in the next 25, 50, and 100 years. The Inventory also demonstrates that additional data, quantification, and research are needed to ensure we continue to increase our understanding of water-dependent natural resources and anticipate and minimize risks to these resources as we move into the future.

OBJECTIVE & SCOPE OF THE INVENTORY

The Environmental Working Group was formed under the work plan developed by ADWR for the WRDC. The Environmental Working Group was tasked to 1) identify current water-dependent natural resources; 2) identify conditions necessary to support them; and 3) prepare a summary of findings and recommendations including needed studies and research. Using available scientific data and methods to complete these objectives, the Environmental Working Group compiled an inventory that identifies the state's primary water-dependent natural resources and characterizes, where possible, the physical conditions of the water that supports those natural resources, which includes the state's rivers, lakes, streams, springs, wetlands, riparian and aquatic habitats, and the flora and animals, birds, fish and other wildlife.
More than 50 professionals from nearly 30 agencies, institutions, non-governmental organizations, tribes, and private sector firms stepped forward to participate in and contribute to the Environmental Working Group. Committee members reviewed and discussed over 100 studies and met at least 25 times to develop and prioritize tasks, gather data, prepare and compile the Inventory, and coordinate with other WRDC Committees.

An early decision of the Environmental Working Group was to assess only water currently in use by natural resources based on existing data. The Inventory is a catalog of current conditions; a snapshot in time. The work plan for the WRDC assigned the Environmental Working Group to determine if current and future water supplies are sufficient to meet current and additional demand. Compiling extensive amounts of research and data into one usable inventory that catalogs water-dependent natural resources was a significant challenge considering the time frame given to the Environmental Working Group. The Environmental Working Group did quantify current flow supporting water-dependent natural resources for 12 of the state's 51 basins for which data was available. Data was not available to identify current flow for the remainder of the basins with perennial flow as well as flow volumes needed to support water-dependent natural resources in the future. Developing the information necessary to satisfy these needs would be a lengthy scientific endeavor requiring additional information on perennial stream flow and an assessment of future cultural uses, effects of changing climate, and how these factors will affect riparian and aquatic habitats and the wildlife they support.

CONTENT OF THE INVENTORY

The Environmental Working Group cataloged the diverse and unique water-dependent natural resources of Arizona by displaying the information as tables, maps and basin summaries. In addition, maps were created for each of Arizona's 15 counties to show this information at the county level. These materials identify groundwater sub-basins, watersheds, and counties associated with each groundwater basin.

A vast array of water-dependent natural resource data is clearly presented, including:

- The number and type of riparian, aquatic and/or marshland habitat dependent species (e.g. amphibians, birds, fish, etc.)
- Identification of species that are listed as endangered, threatened or candidate species under the Endangered Species Act
- Areas of Critical Habitat designated by the U.S. Fish and Wildlife Service under the Endangered Species Act
- Identification of major perennial streams and tributaries and their cumulative miles of flow
- Quantification of baseflow, evapotranspiration, and total flow supporting water-dependent natural resources for perennial streams in12 groundwater basins where data was available
- Identification of perennial streams with flood flow components
- Streams classified as Outstanding Arizona Waters pursuant to A.A.C. §R18-11-112
- ADWR information related to instream flow water rights
- Important water resources within federal or state designated conservation and recreation lands such as national and state parks, wilderness areas, national conservation areas and others
- Important Bird Areas identified by the Arizona Audubon Society
- Identification of water courses that may be supported by effluent or other water discharges and the associated volumes
- Identification of Effluent-Dependent Waters pursuant to A.A.C. §R18-11-113
- The number, flow range and cumulative discharge volumes of major and minor springs
- The number of large and small reservoirs and the associated storage volumes
- The number of stockponds and wildlife catchments
- Water-based recreational values
- Federally designated Wild and Scenic Rivers pursuant to the Wild & Scenic Rivers Act

Information related to some categories of water-dependent natural resources as well as important information about legal and institutional characteristics of particular water resources was not included. For example, intermittent and ephemeral streams, which have ecological and hydrological significance (Levick et al., 2008) are not characterized or mapped here. Also, some water in a stream may be the subject of a water right under state or federal law. Some of these rights are well-settled and others have not been quantified and/or adjudicated. While this type of information has an important bearing on water resource planning, it was beyond the scope and capacity of the Working Group to catalog this information.

QUANTIFYING THE WATER FLOW FOR WATER-DEPENDENT NATURAL RESOURCES

While each table contains a significant amount of information, the Environmental Working Group wanted to be able to show the quantifiable current water flow supporting water-dependent natural resources. After evaluating available data and consulting with members of the scientific community (see Methodology Section), the Working Group concluded that it was feasible to develop a set of quantitative estimates of flow volumes for a subset of the state's rivers, which includes 12 of Arizona's 51 groundwater basins (Aqua Fria, Aravaipa Canyon, Bill Williams, Cienega Creek, Lower San Pedro, Safford, Salt River, Santa Cruz AMA, Tonto Creek, Tucson AMA, Upper San Pedro, and the Verde River). The tables for the other groundwater basins do not include estimated flow volumes because the comprehensive data and research to access and then quantify a specific water flow is lacking.

The Environmental Working Group recognized there are different methods and data available for estimating flow volumes and that results may vary depending upon which methods and data are used. Rather than select one technique and rely on one set of estimates, two sets of estimates were developed. This approach provides some advantages. First, given the goal was to develop a first approximation rather than a precise set of flow estimates, a range of flow estimates for watersheds is more appropriate. Second, generating a range of estimates enables the members of the WRDC, Environmental Working Group, and scientific community to better understand sources of variation in the different methods and data, which will lead to future refinements in methodologies and the overall certainty of results. To develop a general estimate of current flow volumes supporting water-dependent natural resources, the Working Group started by identifying the components of flow that support these resources. Based on studies of water budgets and discussions with experts in hydrology, two components were identified:

> Baseflow is the part of stream flow originating from groundwater discharge and that sustains year-round flow.
>
> Evapotranspiration (ET) refers to the combined amount of water evaporated from riparian soil, open water surfaces, and transpired by riparian vegetation.

The Environmental Working Group did not include two other components, groundwater underflow and flood flow, in the calculations. Ideally, each of these components would be used to calculate water flow estimates but available data were limited. For example, estimates of groundwater underflow, which is subsurface water that flows out of a basin into the next down-gradient basin, are derived through modeling rather than direct measurement. Similarly, flood flows are difficult to incorporate into a quantitative flow estimate. A practical method for integrating these parameters into a quantitative flow estimate was unavailable, and therefore, they were omitted from the estimate.

The omission of the groundwater underflow and the flood flow does not minimize their significant role in the formation and functioning of riparian and aquatic ecosystems. Flood flows, including snowmelt runoff, play a vital role in the transport of sediment, recharge of floodplain and alluvium, recruitment and dispersal of riparian plant species and, among other things, trigger breeding in some aquatic species. In addition to the annual total volume of flood

flows, factors such as flood frequency, timing, and duration are also important components that affect a groundwater basin.

Therefore, in the 12 groundwater basins where it was feasible, the Environmental Working Group estimated the flow volume as a sum of the baseflow and riparian evapotranspiration. As stated in the recommendations, it would be useful to have more complete information about the other 39 groundwater basins. The baseflow and ET estimates developed by the Environmental Working Group provides a first approximation of the flow volumes currently supporting water-dependent natural resources, such as aquatic and riparian habitat for fish and wildlife. Presented in the same units of measure as the information developed by the Supply and Demand Working Group, the flow estimates for the 12 basins provide an important baseline that can be used to assess opportunities to maintain or enhance these resources as well as potential impacts to natural resources from future water developments.

ARIZONA AND WATER-DEPENDENT NATURAL RESOURCES

The tables, maps, and summaries for the 51 groundwater basins comprising this Inventory demonstrate the uniqueness and diversity of the state's natural resources. These natural resources are integral to Arizona's overall environment and character as well as to the state's economy. Water in the environment serves important and obvious functions such as drinking water for terrestrial species, water for plants, and aquatic habitat for fish and other species. It supports riparian vegetation that provides cover, food, shade, and sites for wildlife nesting and foraging. Flows of water in the environment also serve plants and animals in less obvious ways such as modulating temperatures, triggering reproduction or other life-cycle changes, contributing to nutrient and waste cycles, and maintaining the form and function of river channels in a manner that affects the functioning of the larger ecosystem. Indeed, freshwater ecosystems are complex systems in which flowing water is a central component (Annear et al., 2002; Nadeau & Megdal, 2011; Silk & Ciruna, 2004).

On the whole, riparian areas are among the most biologically diverse, abundant, and productive in North America and are especially important in semi-arid areas (Briggs, 1996). Sensitive wildlife species occurrences are tracked by Arizona Game and Fish Department through the Heritage Data Management System (HDMS). According to HDMS, 78 obligate aquatic species (those that can only live in water) including 35 native fish have been documented. Additionally, HDMS tracks 68 riparian species (those that can only live in riparian areas), which include birds, mammals, reptiles, amphibians, and invertebrates. There are also 20 species of insects and 62 plant species dependent on aquatic and riparian systems. Most wildlife relies on water in the environment (Poff et al., 1997). Eighty percent of all vertebrates spend some portion of their life cycle in riparian areas, and the majority of Arizona's threatened and endangered vertebrates depend on riparian habitat (Zaimes, 2007). The connectivity of these habitats is important as well; streams and riparian areas serve as corridors for wildlife movement and as key flyways for migratory birds (Kirkpatrick & Conway, 2007).

Ecosystems throughout Arizona depend not only on the existence of a certain quantity of water but also on the magnitude, frequency, duration, timing, and rate of flow. Each is important and may affect such factors as water quality, energy sources, physical habitat, and biotic interactions. Changes in any of these aspects of a flow can affect the ecological integrity of a water dependent area (Nadeau & Megdal, 2011). Location of a particular flow also matters. Water for natural

resources needs to be understood within the context of occurring along a particular segment of stream as well as in relation to a larger system.

The health of Arizona's waters can be affected by actions taken throughout a watershed. For example, higher elevation forested watersheds provide much of the surface water and groundwater recharge in the state. It has been estimated that forested watersheds of Arizona contribute nearly 90% of the total streamflow in the state (Ffolliott & Thorud, 1975) and serve as important recharge areas for large regional aquifers (Pool, Blasch, Callegary, Leake, & Graser, 2011). Changes to land and watershed management may change the timing and rates of recharge to these aquifers (National Research Council [NRC], 2008).

The contributions that water in the environment makes to human life are ubiquitous that they may be overlooked amid the complexities of ecosystem and human social activity. Finding a consistent and appropriate way to assess their value may provide valuable information to decision makers in natural resource management. The concept of "ecosystem services" was developed as a framework to assess these values. Ecosystem services are the ways by which natural resources produces fundamental resources, the natural assets, used by humans (Ecological Society of America [ESA], 2000). Water-dependent natural resources throughout Arizona provide important ecosystem services that may include clean water (by supporting water quality), clean air, flood control and erosion control (by supporting healthy riparian areas), a variety of recreational opportunities, and sustainable water supplies (by contributing to groundwater recharge).

The 51 tables and maps of the groundwater basins demonstrate the importance of water to sustain the natural resources of Arizona. These natural resources are not only important to plants and animals. Rivers, springs, and other water resources are also culturally important to local communities, including Arizona's Native American tribes, and sustain places and provide materials that are culturally important to tribes and other communities. Water in rivers, lakes and streams is also important to Arizonans and those who visit Arizona who care about natural beauty, outdoor recreation, open space, and wilderness values, or just that such water dependent natural resources continue to exist for their children or grandchildren to experience. (Southwick Associates, 2002) "Water in the desert" is a quintessential characteristic of the Arizona landscape and an important part of the state's heritage.

ECONOMICS OF WATER-DEPENDENT NATURAL RESOURCES

Arizona's water-dependent natural resources offer notable economic opportunities because they attract large numbers of tourists, anglers, hunters, and other outdoor recreationists, while enhancing local property values and business revenues. Fishing, hunting and wildlife watching recreation activities alone generate billions of dollars in retail sales each year.

Economic studies for the state of Arizona, conducted by Southwick Associates Inc. (2003) and Arizona State University (Silberman, 2001), identified the economic benefits from hunting, fishing and wildlife watching. The studies show these wildlife-based recreation activities generated a total economic impact of $2.8 billion in 2001, which includes retail sales and their overall ripple effect through the economy. The table below illustrates the total expenditures from retail sales alone for wildlife-based recreation activities in 2001.

County	2001 Hunting/Fishing Total (Millions)*	2001 Non-Consumptive Total (Millions)*	Totals (Millions)
Apache	$62.8	$24.8	**$87.6**
Cochise	$12.7	$13.7	**$26.4**
Coconino	$101.2	$46.6	**$147.8**
Gila	$39.4	$11.5	**$50.9**
Graham	$7.3	$7.0	**$14.3**
Greenlee	$2.5	NA	**$2.5**
La Paz	$17.8	$1.8	**$19.6**
Maricopa	$409.1	$368.3	**$777.4**
Mohave	$79.9	$30.9	**$110.8**
Navaho	$33.3	$24.4	**$57.7**
Pima	$84.5	$173.5	**$258.0**
Pinal	$20.0	$50.8	**$70.8**
Santa Cruz	$13.9	$11.9	**$25.8**
Yavapai	$40.0	$38.9	**$78.9**
Yuma	$34.2	$12.3	**$46.5**
Statewide	**$959**	**$816**	**$1.7 Billion**

Figure 1. Wildlife-Based Recreation Retail Sales in 2001

For a more localized example, in the San Pedro Riparian National Conservation Area the natural landscape attracts enough visitors to bring in $17.0 to $28.3 million to the local economy (Orr & Colby, 2002)

Southeastern Arizona was identified as the number one birding site in a study evaluating birding economics and demographics in the United States (Kerlinger, 1993). Of the U.S. total birdwatching economic output ($84 billion), over $1.5 billion may be attributed to Arizona in 2001. According to the U.S. Fish and Wildlife Service (2003), approximately 22% of Arizona residents participate in bird watching activities. With the national bird watching population estimated at 50 million people, there is clearly a large pool of U.S. citizens who could be and have been enticed to visit Arizona for birding. This means the Arizona birding industry may have the potential to expand, attract more visitors, and become an even greater economic benefit to the state (Orr & Colby, 2002).

Another water-related component to Arizona's economic success is the value added by riparian areas, wetlands, and natural waterways near private property. This added value has been explored by researchers in the Santa Cruz River Basin more than any other area in the state. Studies conducted in Tucson and the surrounding metropolitan areas all agreed that "homebuyers…place considerable value on those sections of the riparian corridor that support …riparian species" (Bark-Hodgins, Osgood, Colby, Katz, & Stromberg, 2009). Specifically, Bourne (2007) showed that homes closer to riparian areas carry a "premium" that can increase the home's value by 5.8%. Colby and Wishart (2002) support this estimate of additive home value and also state that vacant land may carry an increase of 10-27% depending on its proximity to riparian areas. Finally, another study showed that an increase in general "greenness" contributes to increased property values (Bark-Hodgins, Osgood, & Colby, 2006).

In summary, wildlife related recreation, outdoor recreation activities, and close proximity to riparian areas all produce notable economic benefits for individuals and businesses across Arizona. Many watchable wildlife dollars are often spent at retailers, manufacturers, and support services in rural or lightly populated areas and constitute a larger contribution to those economies than for more urban and highly populated areas. Thus, the economic contributions of water-dependent outdoor recreation activities are particularly important to Arizona's rural economic base.

POTENTIAL RISKS TO WATER-DEPENDENT NATURAL RESOURCES

The Environmental Working Group did not attempt to assess potential risks to the state's water-dependent natural resources, trends affecting these resources, or the level of legal or other protection afforded to water supporting these resources. Risks to particular resources may exist; human activities and natural events have caused substantial alterations to riparian areas (Zaimes, 2007). The risk to a particular resource will depend on a variety of circumstances that deserve consideration in the future.

RECOMMENDATIONS

This Inventory is a unique accomplishment in cataloging a wide range of research and data into one place, thus providing a snapshot of Arizona's water-dependent natural resources that we enjoy. From the various work involved in compiling this Inventory, the Environmental Working Group proposes the following recommendations:

1. The Working Group recommends that the Inventory be a standalone document that could be used to inform local, regional and statewide decision makers and water resource planners when it comes to issues involving Arizona's water-dependent natural resources.

2. The Inventory demonstrates that additional data and research is needed. Additional knowledge of the condition and trend of resources that depend on water, particularly those that comprise the riparian and aquatic communities, are needed to guide future land and water resource planning. Various data and research projects can be identified but the following are four key examples of such further data and research:

   a. A comprehensive, spatially-explicit inventory of the state's riparian habitat is needed to better plan for the management of the riparian resource.

   b. A complete and current field assessment of the extent of perennial and intermittent surface water would enable a better understanding of how to manage surface water in the future.

   c. Water planning efforts have benefitted from development of detailed modeling data on the relationship between groundwater and surface water. Additional work is needed to characterize this connection in other basins to aid communities in efforts to manage water sustainably for both people and the environment.

   d. The Inventory was able to quantify the current flow supporting water-dependent natural resources in portions of 12 of the 51 groundwater basins. Additional work is needed to identify and quantify such flow in all of Arizona's groundwater basins.

3. Evaluation of future water supply options should include consideration of the potential impacts on and risks to water-dependent natural resources.

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